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Final Report: Multi-angle Light Scattering Device for Aerosol Particle Detection

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611103

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Christopher M. Sorensen

5d. PROJECT NUMBER

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7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT
The goal of this work was to build a device to study light scattering by irregularly shaped particles and analyze that scattering from a unique perspective so that light scattering can be used to detect pathogenic and explosive aerosol materials, and discriminate between them and naturally occurring ambient particles in a real-time, field-implemented instrument. Such an instrument is a primary defense need. The major road block to the use of light scattering for nefarious aerosol detection and discrimination lies in the fact that the particles involved are usually irregularly shaped, and light scattering from such particles is not well understood. This proposal addressed this

15. SUBJECT TERMS
Light scattering apparatus

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Christopher Sorensen
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					785-/53-2162

Report Title

Final Report: Multi-angle Light Scattering Device for Aerosol Particle Detection

ABSTRACT

The goal of this work was to build a device to study light scattering by irregularly shaped particles and analyze that scattering from a unique perspective so that light scattering can be used to detect pathogenic and explosive aerosol materials, and discriminate between them and naturally occurring ambient particles in a real-time, field-implemented instrument. Such an instrument is a primary defense need. The major road block to the use of light scattering for nefarious aerosol detection and discrimination lies in the fact that the particles involved are usually irregularly shaped, and light scattering from such particles is not well understood. This proposal addressed this deficiency by constructing a multi-angle light scattering device to measure the scattering matrix of irregularly shaped particles. Unique features of the device are simultaneous multi-angle detection and detection from extreme forward (0.3 deg) to backward scattering angles (160 deg). We are currently measuring scattering from Arizona road dust, various sizes of abrasive grits and planning soot studies, some cloud processed. The project has applied our unique Q-space analysis method to find power functionalities. The device is at the center of a comprehensive program to study light scattering that will involve and train graduate, undergraduate and high school students.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received	Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received	Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

"Experimental study of light scattering from irregularly shaped particles" Y. Wang, A. Chakrabarti and C. M. Sorensen, contributed talk at the 33rd annual conference of the Am. Ass. Aerosol Res., Oct. 20-24, 2014, Orlando, FL.

Number of Presentations: 1.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

November, 2014 Sorensen was named a Fellow of the AAAS.

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Yuli Wang	0.00	
FTE Equivalent:	**0.00**	
Total Number:	**1**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Christopher M. Sorensen	0.20	
FTE Equivalent:	**0.20**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED	Discipline
Brendan Heffernan	0.00	BS Physics
FTE Equivalent:	**0.00**	
Total Number:	**1**	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 1.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 1.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Our most significant progress to date (Dec 1, 2014) is the construction of the multi-angle light scattering detection device. This device allows for simultaneous measurement of scattering for 31 angles ranging from 0.3 to 160 degrees. This device measures all the relevant components of the scattering matrix. We have also built a device for backscattering for angles ranging from 170 to 180 degrees. This device measures scattering for both linear polarizations. We separated these two devices because the backscattering gives us special problems that need to be worked out before we combine the two devices for simultaneous detection at 0.3 to 180 degrees.

We have begun studies of scattering from three different sizes of Arizona road dusts and five different grit sizes of alumina abrasives. With our small angles (and unlike all previous scattering work), we are able to obtain Guinier regimes for these systems despite their large sizes (as large as 15 micron). Hence an optical measurement of size is obtained. At larger angles, hence larger q values, where q is the scattering wave vector, power laws have been found. This result is new and in corroboration with our previous work involving spheres, reanalysis of dust scatting data and perturbed sphere theory predictions. Thus our hypothesis that Q-space analysis will yield power laws with quantitative exponents is unfolding to be true. Future work involves rebuilding the apparatus to close a gap in the scattering angles near 15 degrees, obtain and use more sensitive detectors, and then a comprehensive study of scattering for a wide range of particle shapes, sizes and compositions.

Technology Transfer